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INFORMATION REPORT INFORMATION REPORT

CENTRAL INTELLIGENCE AGENCY

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SOURCE EVALUATIONS ARE DEFINITIVE. APPRAISAL OF CONTENT IS TENTATIVE.

The following symbols (other than for tool geometry) are used in this report:

v	=	cutting speed	meters/min. (v_T cutting speed for given T value)
f	=	depth of cut	mm.
e	=	feed	mm/rev.
σ_B	=	tensile strength	kg/mm^2
H_B	=	Brinell hardness	kg/mm^2
H_{RA}	=	Rockwell hardness, A scale	(62.5 kg. load)
T	=	tool life	min.
H_g	=	surface roughness, root mean square, in microinches.	
Δ	=	tool wear	mm.
t	=	machining time	min.
S_f	=	wear resistance	(A comparative figure for a given test)

6c

Symbols for tool geometry are given in Fig. 1.

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1. It was taken into consideration at the Machine Technological Institute in Budapest that optimum tool geometry should cover a wide range of commercial materials and technological data. Generally tool life values were plotted (cutting force and surface roughness only measured and kept with normal limits)

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STATE	X	ARMY	X	NAVY	

(Note: Washington distribution indicated by "X"; Field distribution by "#".)

except in the case of fine machining, where the surface roughness value was the most important:

a. Conventional tool bits

	Plain carbon steel $60 < \sigma_B < 90$ kg/mm			Cast iron H_B 140-180 kg/mm^2		Mg-Al alloy (details not recalled)
φ	45%	70°	30%(1)	45%	90°	70%
$\alpha \cdot \alpha'$	10°	7°	7%	5°	5°	10%
γ	- 5%	- 5%	- 5%	- 5%	- 5%	+ 7%
γ'	+10%	+10%	+10%	+10%	+10%	+10%
λ(2)	0%	0%	- 2%	0%	0%	+ 2%
τ	15%	15%	5-7%	15%	10%	10%
r	1mm.	1	1.2(?)	0.8mm.	1	0.6mm.

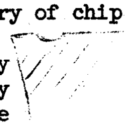
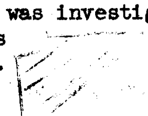
(1) φ = 30% when machining steel was not generally successful; as it is very useful, especially for finishing operations, it can be applied at t = 0.1 - 0.4; s = 1 - 2mm. ($t \times s \leq$ 0.4 mm^2) values, but a 30 - 50% loss in tool life may occur.

(2) λ - the definition is different from Russian and the same as German (German λ = +2° is given in Russian literature as λ = -2°).

b. "Throw-away" bits

As it seemed to be economical to use "throw-away" insert bits similar to some American ones recently put on the market [redacted] 25X1 for cemented carbide tools, much effort has been made to find some possibility of applying alumina inserts, possibly in the same toolholders. Fig. 2 shows some of them and though development work on them at many enterprises gave satisfactory results it was still not possible to judge its general usefulness.

c. Chip Breaking

The geometry of chip breakers was investigated. It was found that grinding of grooves  or steps  in mass production is not practically possible. Experiments showed that incorrectly designed chip breakers may easily lead to breakage of the edge of the tool. It is not recommended for use, and where a mechanical chip breaker cannot be applied chip breaking is still an unsolved problem. (Mechanical chip breakers will be discussed later with tool holders.)

d. Technological Data

The empirical equation $T = \phi(v, t, s)$ was determined for steel and cast iron (to given σ_B and H_B values). It was suggested that T = 90 min. is a reasonable economic value and data were worked out in the usual way. The formula $v_T = C^x s^y$ can be found in the literature referred to.

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2. All experiments showed that alumina tools should be recommended for finishing and semi-finishing, though under laboratory conditions rough machining and machining interrupted surfaces were possible with greatly reduced tool life. In most cases the nose or/and the cutting edge chipped. Experiments on the use of alumina instead of diamond tools for fine machining failed. It was found that under $f=0.2$mm. and $e=0.05$mm/rev. tool life is very short due to disintegration of the cutting edge. This applies to steel and cast iron. (No experiments were carried out on light metals.) Machining was not satisfactory under $\gamma = 100 - 80$ m/min. Maximum cross section (e x f) is about 2mm^2 in case of steel and 3mm^2 with cast iron. The ratio f/c = 8:1—12:1 is recommended. Maximum cutting speed $V = 1{,}000$ m/min. was reached but chip breaking was not possible and it had no practical use at all.

Vibration Elimination

3. To improve tool life and surface roughness by reducing vibration under heavy cuts by modifying the geometry was possible. Though it was satisfactory in many circumstances it was not possible to determine comparative figures. The geometry is shown in Fig. 3. The 45° flat surface is hand-lapped with a metal-banded diamond file. The experiments were carried out on a very rigid machine by an excessive protrusion of tool shaft and/or exaggerated ratio of the diameters and length of work piece.

Tool Holders

4. Most satisfactory results were found with tool holders with "non-rigid clamping", which means that the tool bit is held in position by means of a spring when not cutting, while during machining the cutting force keeps it in position. The spring may work as a chip breaker as well. The design is shown in Fig. 4. Adjustment is possible, but reground tools (of smaller size) can be used in the same toolholder.

5. Another design with "rigid clamping" is shown in Fig. 5. The adjustment is only in one direction. The clamp works as a chip breaker as well.

6. For "throw-away" bits toolholders were similar to American designs, and were found very satisfactory. The "cover plate" of cemented carbide should be used for chip breaking.

7. Many types of toolholders similar to that shown in Fig. 6 were designed in Czechoslovakia, but despite many advantages it is not easy to apply chip breakers.

Attachment of Tips

8. To attach the ceramic tips, brazing was found possible, but as gluing was satisfactory in all circumstances and is much easier, experimentation on brazing processes was stopped at a very early stage and no details are recalled. Soldering was never tried.

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10. Gluing is recommended only when mechanical tool-holders cannot be used, mainly in the case of form tools or tools used on automatic lathes.

Tip Composition

11. The best-quality tips made by the Electrochemical Laboratory at the Technical University of Budapest, known as LC 96, were of high-purity Al_2O_3. No contamination was detected. Specific gravity was 3.86(?) and size of crystals - measured by polarized light - was 0.1 - 1μ (Both specific gravity and crystal size are largely dependent on the firing process.)

12. Tool bits made by the "Spark plug Works"[1] in Budapest consisted of commercially pure alumina and CrO alloy. The color of these bits was light pink. Specific gravity 3.45(?), crystal size 1 - 10μ . Quality is much inferior to LC 96. (Notch ductility - measured by JZOD test - was higher but wear resistance dropped very rapidly.)

Tool Life Graphs

13. [redacted] 25X1 Some details of the test results may be useful. [redacted]

a. Type of Wear.

It was found that for tool life test wear on "d" surfaces (Fig. 7) should be recorded and plotted against machining time. Though a very ingenious method was worked out by the sister institute in Prague to measure crater wear, this was found not to be characteristic. Cratering occurred only ~~when machining steel~~. While machining ~~aluminum a heavy~~ "built-up edge" occurred and it was necessary to etch this before each measurement. The wear was rather uniform; whenever "peaks" were observed (Fig. 8) elsewhere than on the nose or end of cutting edge, microscopic examination[3] showed irregularity of crystal structure.

b. Test Preparations

As a very large quantity of material was used for tests, uniform machinability properties were checked by means of "master tips", both cemented carbide and alumina. Correction factors were introduced if necessary. Tips were carefully ground as to geometry, and surface roughness (RMS [illegible]) and "edge sharpness"[4] were kept within close limits. It was not possible to get repeated test results more accurate than ± 25%.

c. Short Tests

All attempts to find some shortened tool life test failed. The methods which were investigated are as follows:

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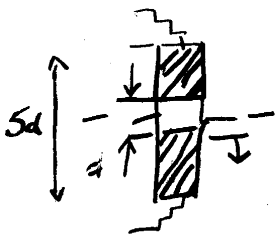
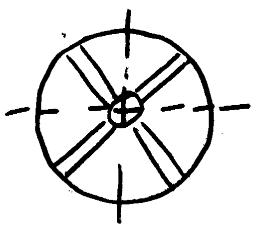
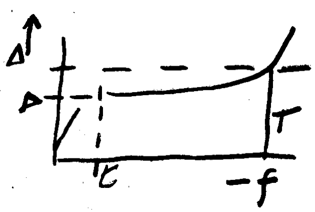


(1). Machining a disc at constant rpm. so that cutting speed (v = 80 - 400 m/min) is continuously increasing. (This method was used by Prof. Schlesinger for HSS tools.)



(2). Similar to previous test, but grooves were milled radially on the disc surface, to produce interrupted surfaces. (This method was described in another report testing German cemented carbides "C" or "3" grade.)



(3). To perform a conventional tool life test but with reduced wear work and to find some mathematical way to calculate final results: Corresponding values of Δ, t were measured (see figure alongside) but it was not possible to deduce Δ_T, T figures.

Cutting and Sharpening.

14. Grinding of alumina bits was quite easy using metal-banded diamond grinding wheels.

Binding metal	:	boron
Hardness grade	:	H
Grain size	:	280 - 320 (mesh number)
Concentration	:	20%
Cooling lubricant	:	Kerosene

Speed, feed, etc. as for cemented carbide.
Surface roughness hg = 0.4 - 1 microinches on both surfaces.

Lapping with boron carbide (600 mesh number) using a cast iron disc, V= 1.5 m/min surface speed, was successful but caused no significant improvement in tool life.
Grinding with ceramic-banded SiC wheels is possible but not economical and quality is much worse. Speed 6 - 10 m/min.; hardness grade (Norton) J - G; 40 - 60 grain size; lubrication sodium-water emulsion.

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Quality Control

15. It was suggested that a close relation between "tool value" and physical - mechanical properties may occur. To prove this a large number of tool bits were tested and theoretical methods applied.

a. "Tool value"

It was decided to choose for "tool value" the tool life at given technological data. During the test steel σ_B = 80 kg/m^2 f = 2 mm e = 0.21 mm/rev v = 400 m/min was kept constant and T at given Δ were recorded.

b. Physical - mechanical properties

It is difficult to select theoretically the properties which are most important. Very little was known about the phenomena of cutting and properties of sintered materials. The main idea was to select properties partly sensitive to the firing process, assuming these to be in close correlation with resistance to cutting stresses.
The properties measured were the following:

Specific gravity
Microstructure
Hardness HR_A
Bending strength (micro bending test)
Compressive strengths
Notch ductility (JZOD test with modified size of specimen)
Wear resistance.[5]

All tests were carried out on the same tool bits and corresponding figures used for mathematical analysis.

c. Mathematical Method.

The method used was "Mehrfache Degression"; correlation and regression coefficients were determined, significant and insignificant variables separated, and regression and correlation coefficient determined again; if there was no significant difference in regression values, the reduced number of variables was enough to deal with.
An empirical equation was found:

$$T = \phi \ (HR_A, S_f)$$

where R = 0.8.

It was definitely proved that this empirical equation is only valid within a very limited range - on tools which are manufactured under the same conditions as the tools chosen for the experiments used to work out the formula.[6]

About 100 or 200 specimens were used to work out the formula and a few thousand tests proved that it is good enough for quality control.

Soviet Tips

16. It was possible to get hold of a few Soviet tool bits TsM 332 to make comparative tests. As it was not possible to get any British or American tool bits the only way to make comparison was to reproduce tests published in periodicals and see the results; these were carried out and the judgement that the Soviet tips are equal to the standards given in British and American journals was based on these test results. There are other Soviet grades as well, the quality of which is much inferior, and they are mostly recommended for machining cast iron. [redacted] 25X1

Cermet Tools

17. There is definitely no Hungarian development work on cermet tools - not even in the early planning stage. It might be that in other fields, possibly that of gas turbines, some research is being carried out.

1. [redacted] Comment: Possibly the Vörös Szikra (Red Spark) Gyar, Polgar ut 8/10, Budapest III. 25X1

[redacted] Comments: 25X1

2. Detailed test results were published in the periodical Gep in November and December 1956 and January and February 1957. [redacted] this magazine is available in the U.K. 25X1

3. The method of microscopic examination is dealt with by Ryskewitch in Oxidceramic, a book published in Germany. It was improved by embedding the alumina in glass having a similar heat expansion coefficient to alumina.

4. The German "Schneidhante Schartigheit" worked out testing methods published in 1954 or 55 by Opitz(?) in Werkstatt und Betrieb or Werkstattstechnik und Maschinenbau.

5. German "Schleitfestigheit", a micro abrasion method used on Al_2O_3 single crystals, published in Zeitschrift für Krystallographie in the 1955 number.

6. This method is discussed in Linder: Statistische Mathematik(?)

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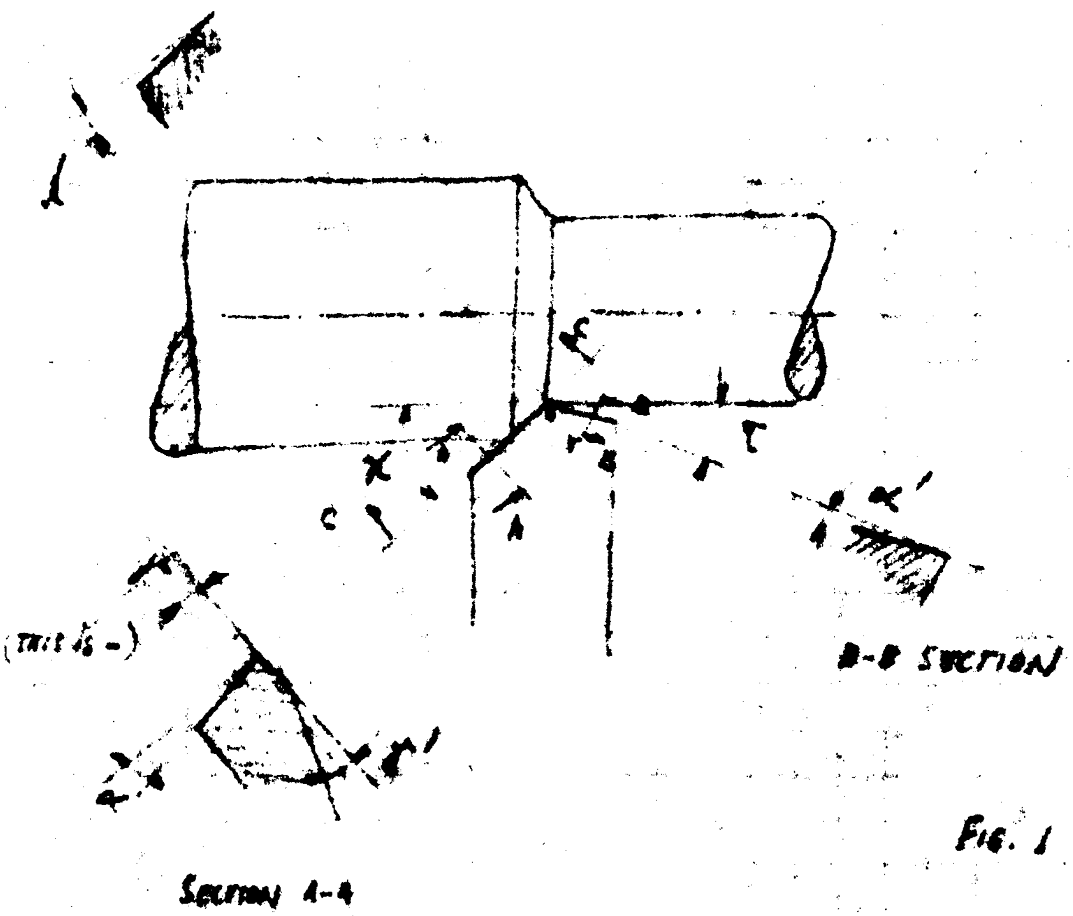
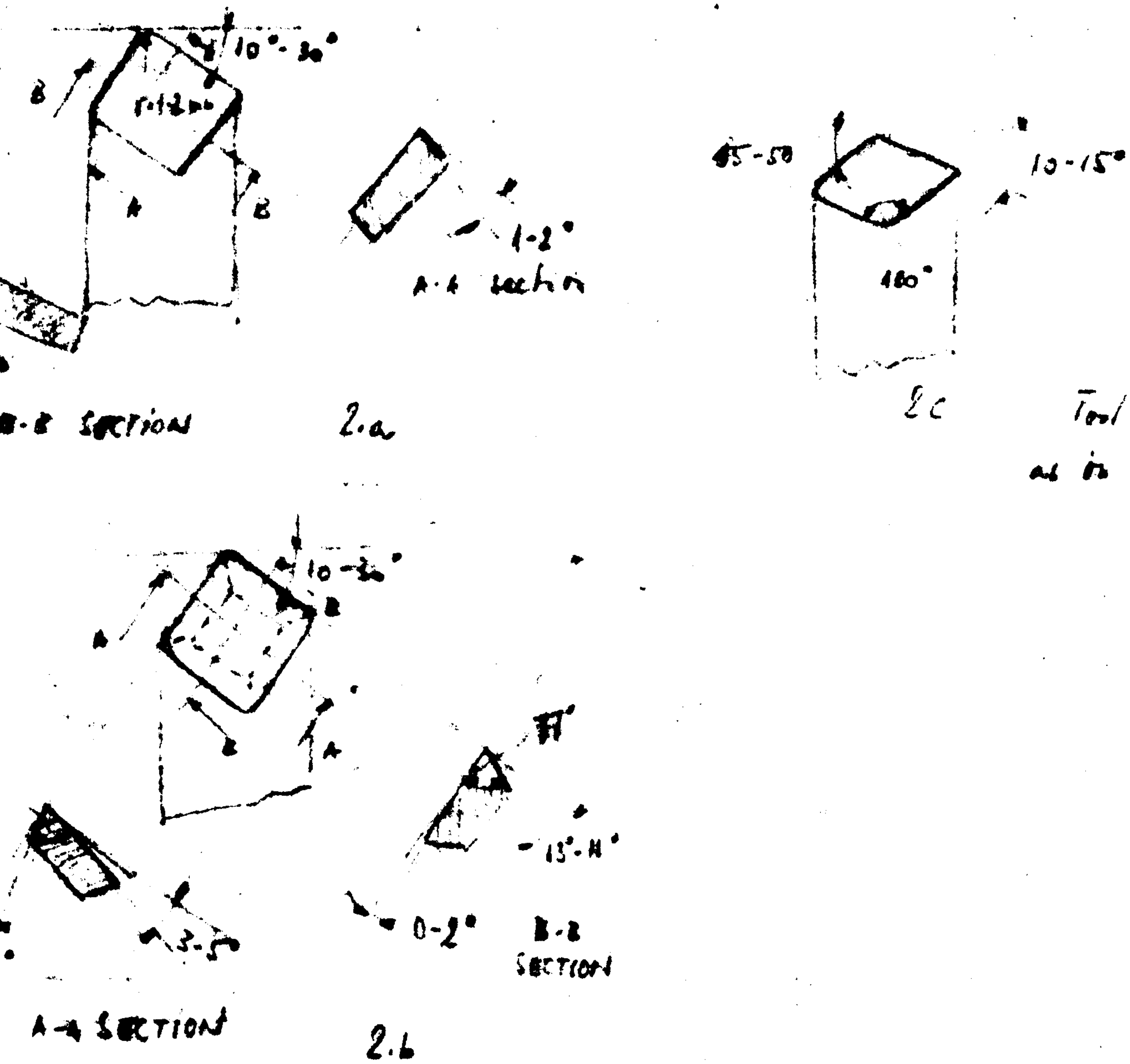
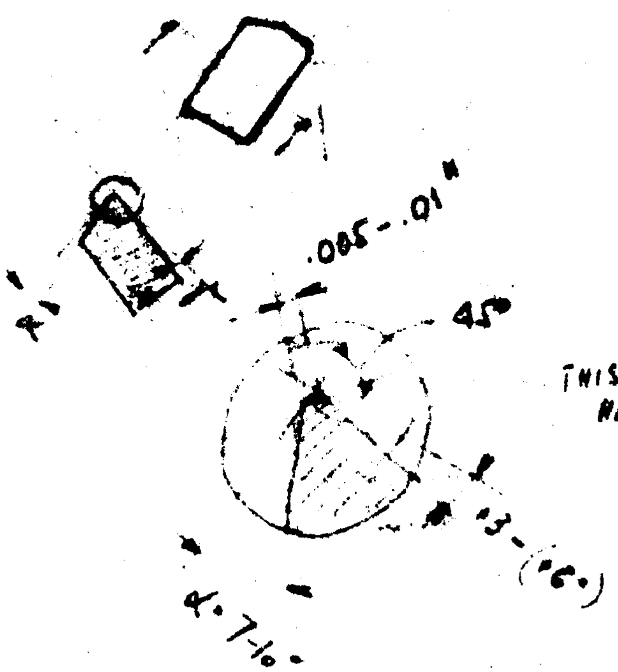


FIG. 1



Tool geometry as in fig 2a.

FIG 2.



THIS 45° FLAT SURFACE IS HAND-LAPPED

FIG. 3.

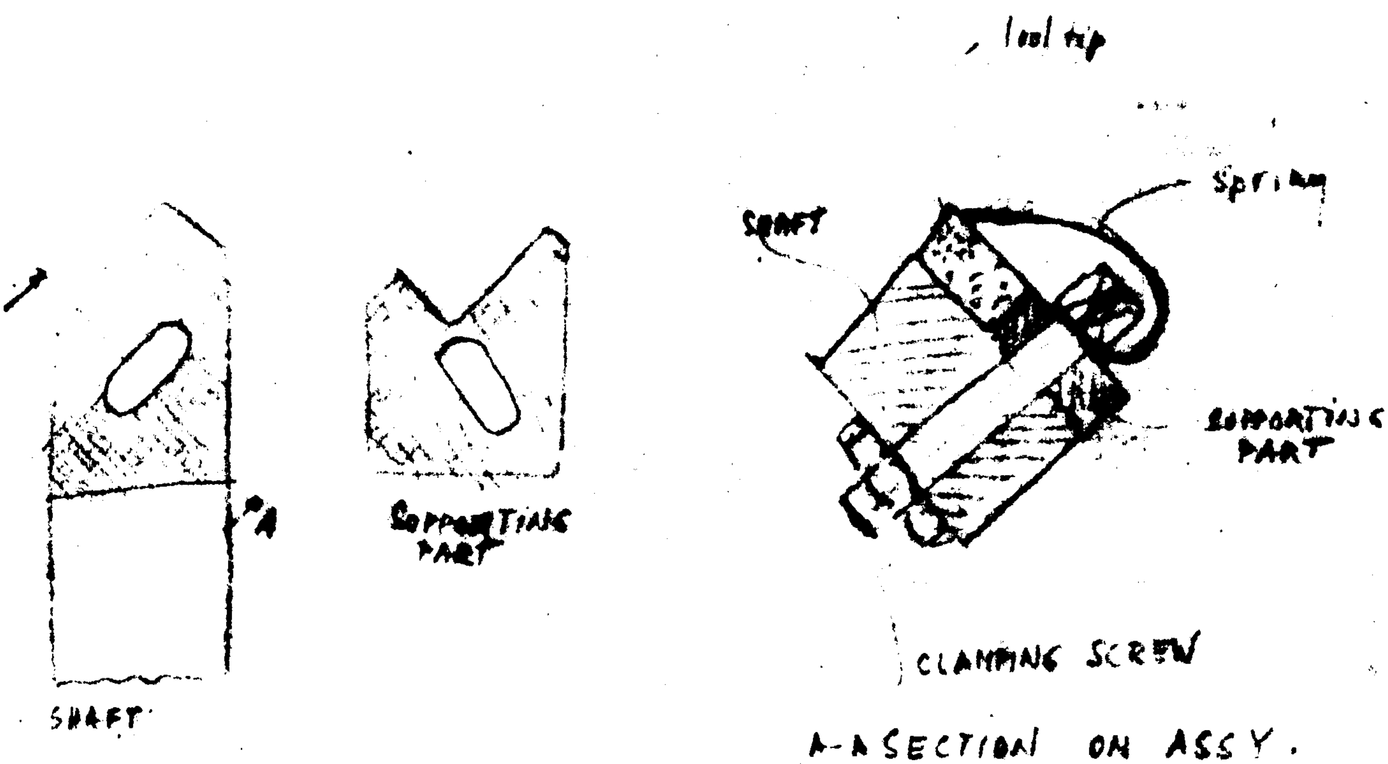

SHAFT
A
SUPPORTING PART
tool tip
Spring
SHAFT
SUPPORTING PART
CLAMPING SCREW
A-A SECTION ON ASSY.

FIG 4

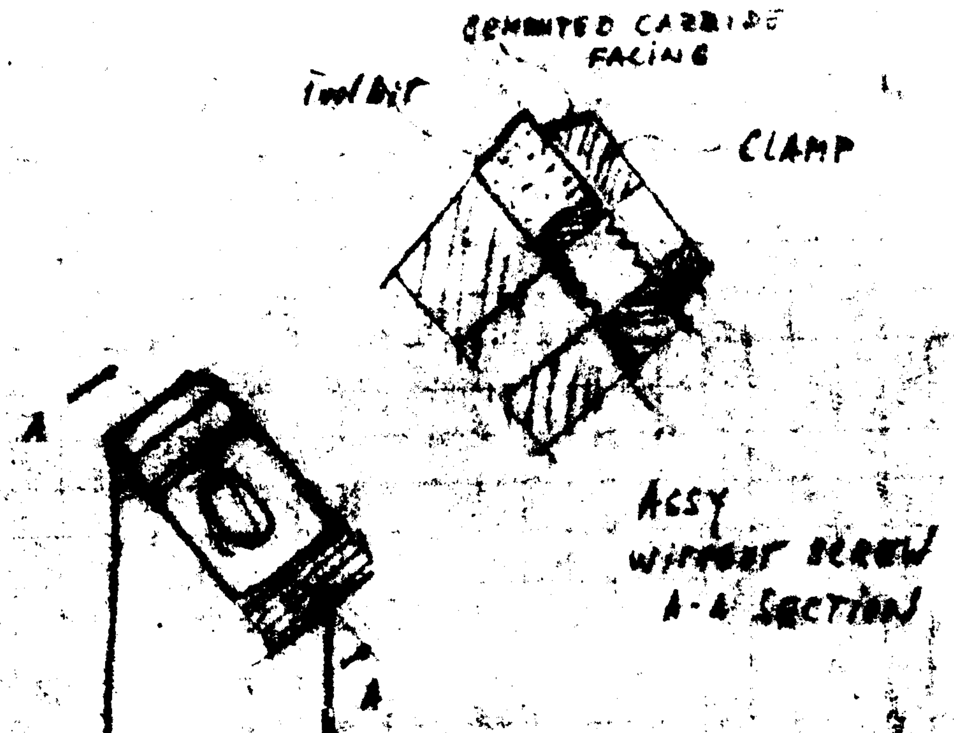


FIG 5

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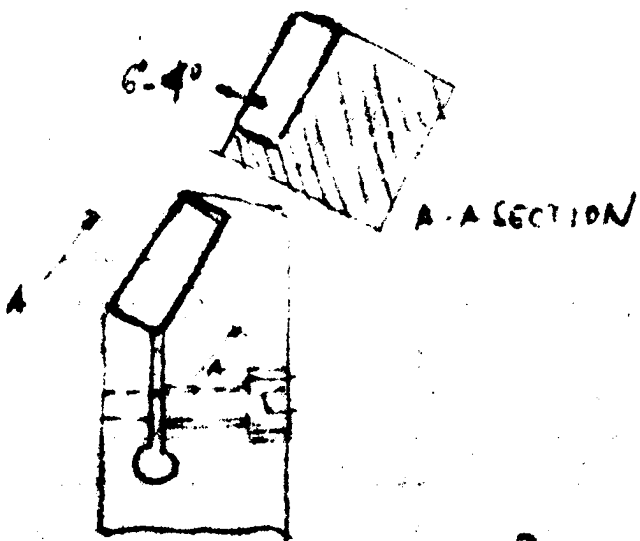

FIG 6.

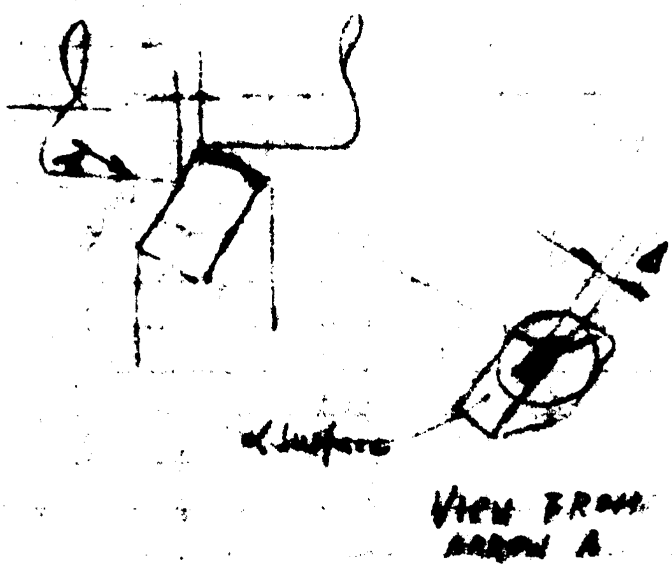

FIG 7

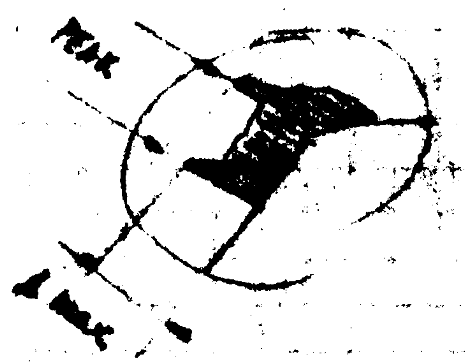

FIG 8